

GRI Perspective on Fuel Cell R&D

**Joint DOE/EPRI/GRI Fuel Cell Technology
Review Conference**

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Outline

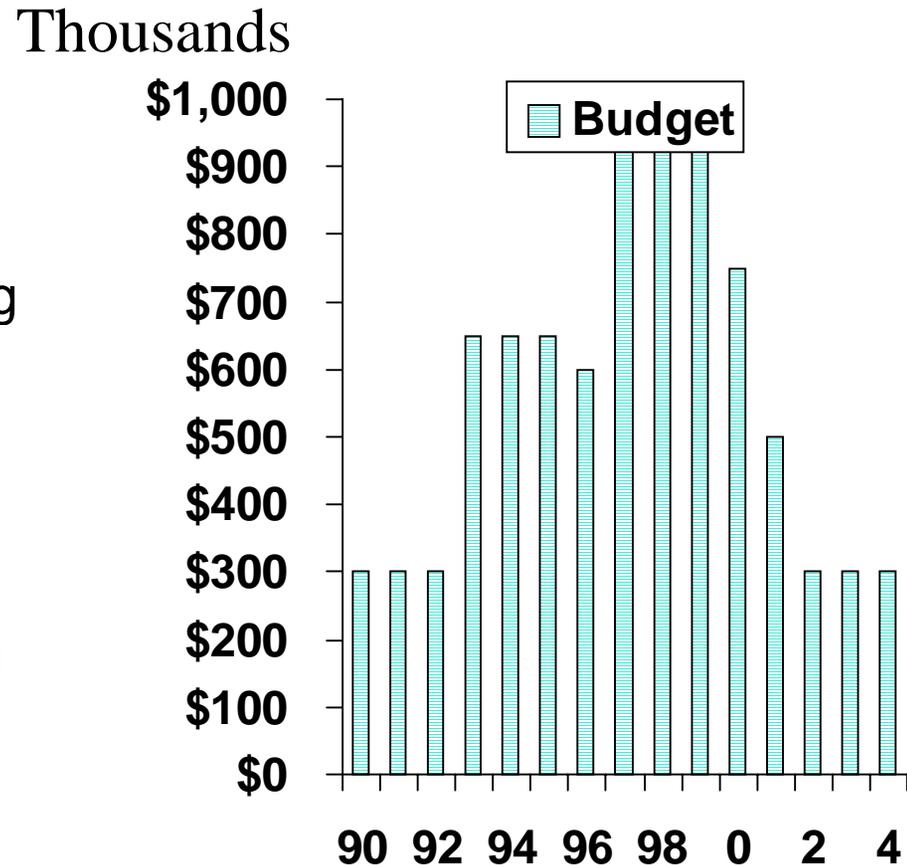
- **Approach**
- **Research**
 - Reduced-Temperature, Electrode-Supported, Planar (RTESP) SOFC
 - Tubular SOFC
- **Conclusions**

Approach: Basic SOFC Research to Complement Advanced Turbine and Engine Development

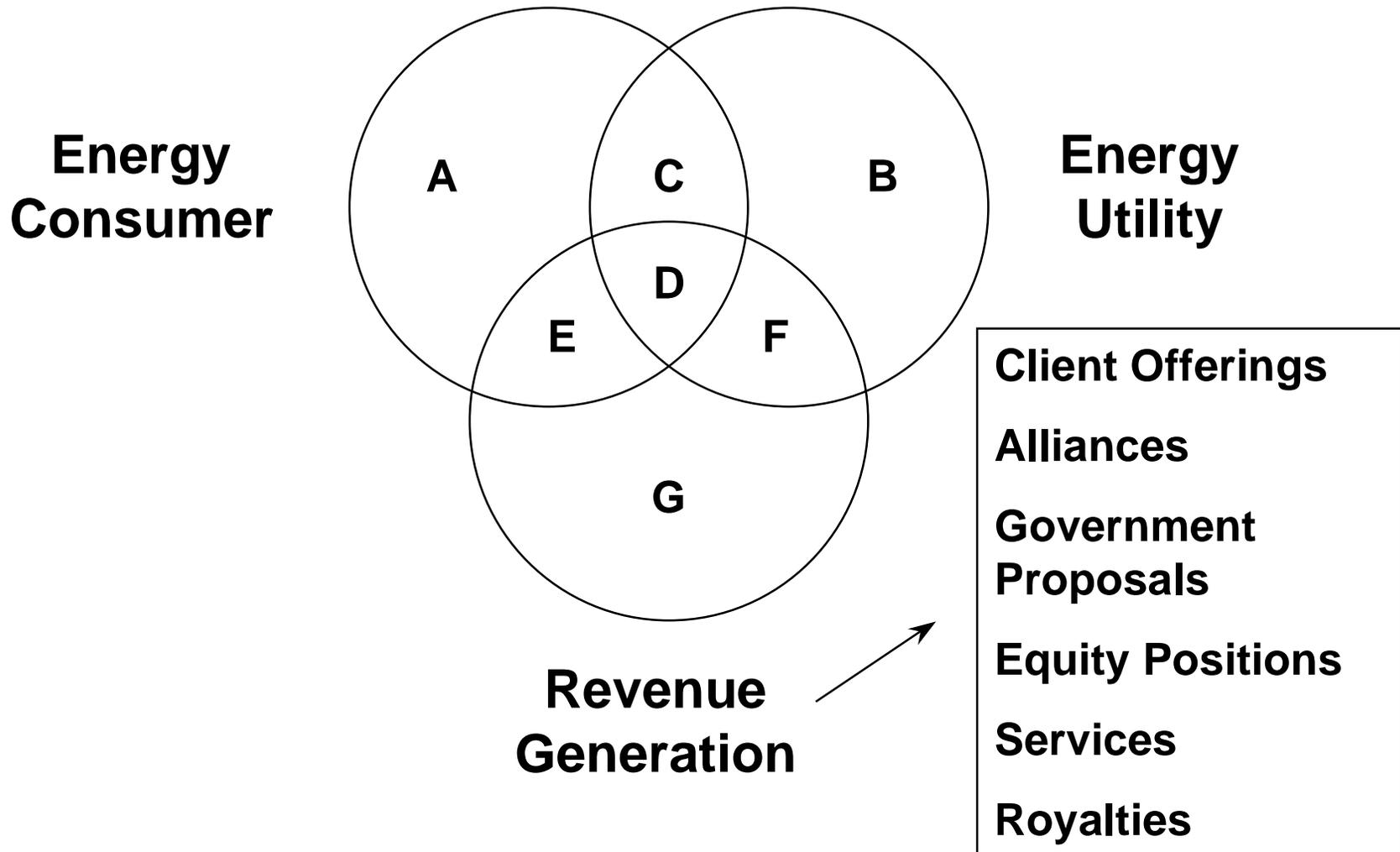
- **Higher maximum and part-load efficiency option**
- **Higher reliability**
 - Few moving parts, negligible emissions, quiet, modular
- **Effective coupling with gas turbines, chillers**

GRI is Focusing on RTESP and Tubular SOFCs

- **Phase I (1990-1996)**
 - RTESP single cells, operating at 650°C
- **Phase II (1997-2000)**
 - Reliable, high-performance RTESP stacks
 - Tubular SOFC cost reduction



Non Tariff-Based Fuel Cell Projects



RTESP SOFCs

- **Thin YSZ electrolyte on thick porous electrode support**
- **Operates at ~650°C instead of 1000°C**
 - Easier sealing, better reliability
 - Low-cost, metallic components
 - Less insulation
- **Uses natural gas directly**
- **High-efficiency and power density and small size leads to low cost**
 - Objective: Total system cost <\$700/kW in small production volumes

Balance of Plant Components	Proton Exchange Membrane (PEM) FC	Reduced-Temperature, Electrode-Supported, Planar (RTESP) SOFC
Fuel Processor	Yes	No
High-Temperature Shift	Yes	No
Low-Temperature Shift	Yes	No
Preferential Oxidation	Yes	No
Water Treatment	Yes	No
Water Management /Condensation	Yes	For start-up only
Humidification	Yes	No
Water Cooling Loop	Yes	No
Fuel Clean-Up	Yes	Yes
Air Pre-Heater	No	Yes (But potentially small or unnecessary)
Insulation	Yes	Yes (But less than for higher temperature SOFCs)
Inverter/Switchgear.	Yes	Yes
Turbomachinery	Used sometimes. Increases efficiency but decreases reliability	No
Controls	Complex	Simpler

**RTESP
SOFC
R&D:
U-Utah /
MSRI**

- **GRI/EPRI R&D Since 1993**
- **NIST-ATP Contract Initiated 11/98**
 - Participants: U-Utah/MSRI/GRI/HBT
 - ~\$3MM over 3 yrs
 - GRI subcontractor: ~\$60K/yr
- **Status**
 - High performance cells
 - <1kW bench-scale stacks
- **GRI/EPRI Patents**

**RTESP
SOFC
R&D:
U-Utah /
MSRI**

- **EPRI/GRI/MSRI/U-Utah Consortium formed**
 - Commercialization and R&D Teams
 - Intellectual property unified
 - Industry partner search underway
 - Pre-commercial prototype in 3-4 years

RTESP SOFC

R&D:

AlliedSignal

- **High-performance single cells**
- **Small stack designs**

**RTESP
SOFC
R&D:
U-Penn**

- **Hydrocarbon-Fueled RTESP SOFCs**
 - Dry methane oxidation
 - Simplified cell materials
 - Cell fabrication method
- **GRI Patents**

**RTESP
SOFC R&D:
U-FL**

- **Bilayer Ceramic Electrolyte Membranes**
 - Syn-Gas Production
 - 550°C Fuel Cells
- **GRI Patents**

**RTESP SOFC
R&D:
Other
Contractors**

- **Lawrence Berkeley
Laboratory**
- **Northwestern University**
- **University of Missouri-Rolla**
- **Institute of Gas Technology**
- **GRI Patents**

**RTESP SOFC R&D:
TDA Research
/Bechtel**

- **Technical Evaluation of SOFC Issues**
 - RTESP SOFC Conceptual System Design
 - Manufacturing Cost Evaluation
 - Residential Applications (Poster)

Tubular SOFCs for >250kW Applications

- **Seal-less design, tolerance to thermal stress**
- **Operability in high-efficiency, pressurized SOFC/turbine cycles**
- **Efficient and Reliable**
- **Reduce Size and Cost**

**Tubular SOFC R&D:
Siemens- Westinghouse,
U-Utah
Lawrence Berkeley N.L.
Penn State U.**

- **Design and fabrication of multi-compartment cells**
 - **Improved linear and volumetric power density**
- **Sintered cell fabrication methods**
- **Materials for improved power density**

Conclusions

- **Low-cost and reliability are needed to expand FCs beyond niche markets**
 - Achieving these targets in small production volumes will accelerate the introduction of FCs
- **Along with other FCs, RTESP SOFCs are an important candidate technology**
 - They eliminate most of the balance of plant
 - They may be the lowest cost option
- **Tubular SOFC cost reductions will lead to very efficient power generation in large applications**
- **GRI is partnering with EPRI, DOE, state governments, its members, and contractors to advance FC technology**